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Washington, D. C. June, 1927

WORK OF THE BELLE FOURCHE FIELD STATION IN 1923, 1924, AND 1925

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INTRODUCTION

This report is one of a series published since 1913 on the results and progress of experiments at the Belle Fourche Field Station and gives also a brief statement of agricultural conditions on the Belle Fourche reclamation project. The Belle Fourche Field Station includes 360 acres, located on the Belle Fourche reclamation project, near Newell, S. Dak. The station is maintained by the Office of Western Irrigation Agriculture of the Bureau of Plant Industry. Other offices and divisions of the Department of Agriculture, in both the Bureau of Plant Industry and the Bureau of Animal Industry, have cooperated in the investigational work.

The work of the station is devoted mainly to experiments in the production and utilization of such crops as are grown on the Belle Fourche project and adjacent areas. The experiments in crop production include crop rotations and tillage experiments on both dry and irrigated land; experiments with pasture grasses; varietal tests of small grain, corn, potatoes, and silage crops; tests of trees for windbreak and ornamental plantings; orchard and small fruits, and the growing of garden vegetables. Figures 1, 2, and 3 show the arrangement of the fields and the location of the experiments in 1923, 1924,

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and 1925, respectively. The crop-utilization experiments were conducted with sheep and hogs. With sheep this work includes pasturing tests and the maintenance of a farm flock, and with hogs it covers pasturing tests and the methods of production of feeder pigs.

WEATHER CONDITIONS ON THE PROJECT

CLIMATIC CONDITIONS IN 1923

The winter of 1922–23 was not severely cold. The precipitation up to May was less than half of the average for the last 16 years.

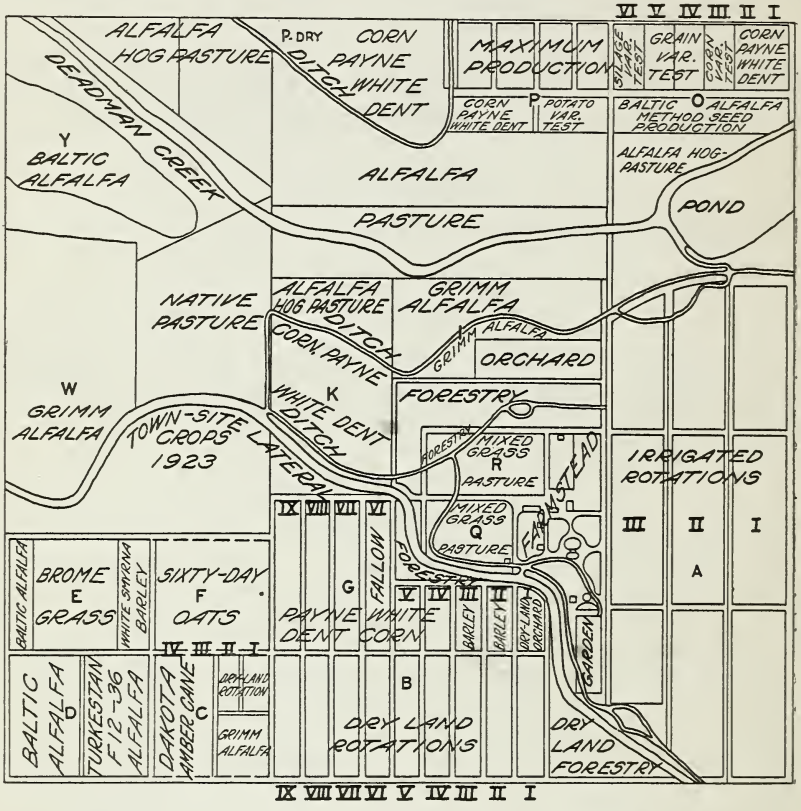

FIG. 1.—Diagram of the Belle Fourche Field Station, showing arrangement of fields and location of crop experiments in 1923

The rainfall from May to September, inclusive, was 21.96 inches, which is more than double that in the same period for the last 16 years. The season was very favorable for crop growth except for small grains, which rusted badly. Very little irrigation was necessary except for the alfalfa. The total precipitation for the year was 27.37 inches, which is the highest on record. There was a frost-free period of 149 days, the last spring frost occurring on May 15 and the first frost in the fall being on October 12.

CLIMATIC CONDITIONS IN 1924

The year 1924 was one of low rainfall, the total precipitation being only 13.80 inches. There was very little snow during the winter months. The spring was cold and dry, and as a result very poor stands were obtained on the spring plowing. The rainfall during the summer months was very meager and of very little value to the crops. Frequent irrigations were necessary, and fortunately irrigation water was available at all times. The early part of October was very wet and delayed the harvesting of the sugar beets and potatoes.

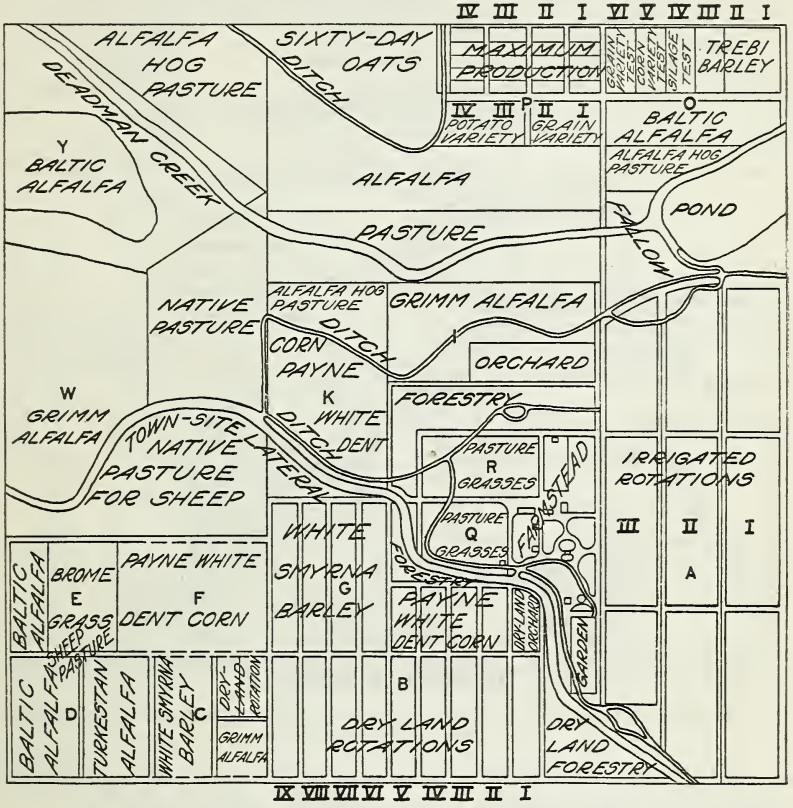

FIG. 2.—Diagram of the Belle Fourche Field Station, showing arrangement of fields and location of crop experiments in 1924

However, the remainder of the fall season was very favorable for work.

There was a frost-free period of 131 days during 1924, the last spring frost occurring on May 26 and the first frost in the fall being on October 5, when the temperature went down to 32° F.

CLIMATIC CONDITIONS IN 1925

The year 1925 was one of exceptionally low rainfall, 10.76 inches being recorded, which is 5 inches less than the average for 18 years.

The months of January, February, and March were very dry. April, May, and June were nearly normal. The rainfall during other months, except December, was very much less than normal. The temperature for the year was very nearly normal, except that in the last week in October the temperature went down to 16° below

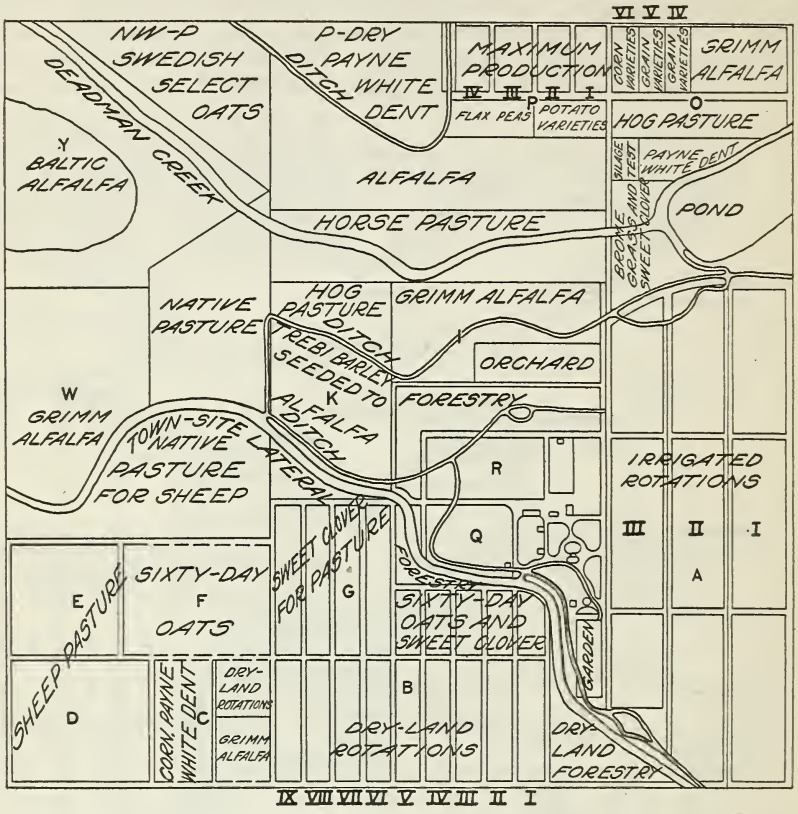

FIG. 3.—Diagram of the Belle Fourche Field Station, showing arrangement of fields and location of crop experiments in 1925

zero (F.). The remainder of the fall season was very favorable for work, plowing and leveling being continued until December.

There was a frost-free period of 148 days during 1925, the last spring frost occurring on May 9 and the first frost in the fall being on October 5. The average frost-free period for the last 18 years was 138 days.

Table 1 presents a summary of the climatological observations made at the Belle Fourche Field Station from 1908 to 1925, inclusive.

TABLE 1.—*Summary of climatological observations at the Belle Fourche Field Station, 1908–1925*

PRECIPITATION (INCHES)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Average for 18 years 1908–1925	0.45	0.42	0.64	1.50	2.54	2.51	2.38	1.47	1.47	1.31	0.52	0.56	15.77
1923	.22	.23	.32	.82	2.31	3.81	4.54	5.35	5.95	3.14	.27	.41	27.37
1924	.08	.88	.70	.81	.68	1.27	1.22	2.00	.72	3.86	.93	.65	13.80
1925	.33	.21	.18	1.53	1.55	3.10	.39	.76	.65	.96	.19	.91	10.76

EVAPORATION (INCHES)

Average for 18 years 1908–1925	------	------	------	4.135	5.600	6.823	8.100	7.040	4.982	------	------	------	36.680
1923	------	------	------	4.478	6.142	6.337	6.798	5.354	4.604	------	------	------	33.713
1924	------	------	------	4.939	5.624	6.541	7.789	6.848	4.806	------	------	------	36.547
1925	------	------	------	5.664	6.329	6.134	8.992	7.577	4.400	------	------	------	39.096

WIND VELOCITY (MILES PER HOUR)

Highest:													
1908–1925	------	------	------	26.8	31.5	20.7	19.4	17.6	26.3	------	------	------	------
1923	------	------	------	14.7	13.2	10.8	7.4	6.6	9.3	------	------	------	------
1924	------	------	------	19.8	15.3	12.7	9.4	11.3	12.3	------	------	------	------
1925	------	------	------	18.4	15.2	11.3	9.2	11.0	15.5	------	------	------	------
Lowest:													
1908–1925	------	------	------	.5	1.0	1.0	1.5	1.0	.9	------	------	------	------
1923	------	------	------	2.0	2.3	1.9	2.0	1.7	1.4	------	------	------	------
1924	------	------	------	1.9	2.0	1.4	1.7	1.0	1.5	------	------	------	------
1925	------	------	------	3.0	2.8	2.4	2.1	1.5	1.5	------	------	------	------
Mean:													
1908–1925	------	------	------	8.0	8.1	6.6	5.4	5.0	5.5	------	------	------	------
1923	------	------	------	6.5	6.6	5.5	4.2	3.5	4.1	------	------	------	------
1924	------	------	------	8.4	6.2	6.5	4.7	3.7	4.4	------	------	------	------
1925	------	------	------	7.1	7.0	5.6	4.3	4.2	4.5	------	------	------	------

MONTHLY TEMPERATURE (°F)

Absolute maximum:													
1908–1925	64	62	87	89	95	108	109	105	105	92	78	66	------
1923	60	59	64	86	88	90	97	89	92	74	69	59	------
1924	51	59	49	79	84	87	96	100	93	80	63	60	------
1925	43	47	73	81	94	96	102	102	99	67	63	61	------
Absolute minimum:													
1908–1925	−37	−36	−20	−3	21	32	40	32	22	−16	−18	−33	------
1923	−14	−32	−11	−3	21	45	54	49	32	16	15	−33	------
1924	−29	−5	−2	24	27	38	46	38	32	27	−1	−24	------
1925	−23	−3	−16	20	29	38	41	44	36	−16	14	−31	------
Mean:													
1908–1925	16	19	31	44	54	65	72	69	59	46	33	20	------
1923	24	17	27	42	55	65	74	67	60	44	39	25	------
1924	12	23	25	43	51	62	72	68	58	51	33	13	------
1925	15	29	35	50	57	64	71	72	62	34	35	24	------

KILLING FROSTS [1]

Year	Last in spring	First in fall	Frost-free period (days)	Year	Last in spring	First in fall	Frost-free period (days)
1908	May 20	Sept. 26	128	1918	May 21	Sept. 18	119
1909	May 17	Sept. 23	128	1919	May 13	Oct. 8	147
1910	May 23	Sept. 25	124	1920	Apr. 29	Sept. 25	148
1911	May 11	Oct. 3	144	1921	May 14	Sept. 29	137
1912	Apr. 21	Sept. 24	155	1922	Apr. 19	Oct. 7	170
1913	May 4	---do ----	142	1923	May 15	Oct. 12	149
1914	May 12	Oct. 4	144	1924	May 26	Oct. 5	131
1915	May 17	Sept. 14	119	1925	May 9	---do ----	148
1916	May 16	---do ----	120				
1917	May 31	Oct. 7	128	18-year average	----------	----------	138

[1] A temperature below 32° F. is considered a killing frost.

CROP ACREAGES ON THE PROJECT

The total irrigable area of farms on the project reported by the United States Reclamation Bureau in 1925 was 64,500 acres. The total cropped area of farms was 53,120 acres, included in 824 farms, or 82 per cent of the project.

Table 2 shows the total acreage for all crops and the acreage devoted to each crop from 1913 to 1925, the figures being obtained from the Bureau of Reclamation.

Alfalfa is the principal crop on the Belle Fourche project and occupies more than a third of the cropped area. Corn is next in importance and occupies about one-fifth of the cropped area. The remainder of the cropped area is devoted to sugar beets, small grains, and miscellaneous crops. As the livestock industries develop on the project more attention must be paid to the growing of feed grain, particularly corn and barley. The sugar-beet acreage in 1924 was the largest on record, 1,281 acres. Cucumbers were first grown as a commercial crop on the project in 1925. The average acre yield was estimated at 250 bushels, and yields as high as 500 bushels were reported. The price paid was very satisfactory to the growers.

TABLE 2.—*Acreage of the principal crops grown on the Belle Fourche reclamation project, 1913–1925*

Year	All crops	Alfalfa hay	Alfalfa seed	Barley	Corn	Native hay	Oats	Pasture	Wheat	Sugar beets
1913	32,568	7,388	1,576	744	1,859	2,533	5,343	285	13,096	--------
1914	36,709	9,745	1,416	1,448	4,415	2,236	6,392	3,604	7,885	--------
1915	43,063	16,152	284	1,613	4,470	2,782	4,440	3,273	7,747	--------
1916	46,909	17,945	4,177	2,740	3,846	2,121	4,119	6,132	7,554	--------
1917	50,026	19,702	942	2,286	2,902	4,475	4,955	6,100	5,122	--------
1918	52,445	20,467	342	1,636	2,068	3,209	4,331	8,894	9,563	--------
1919	56,255	24,804	842	1,351	2,903	3,290	3,665	6,922	10,742	978
1920	59,850	26,040	752	1,695	3,272	2,820	4,864	8,390	9,850	1,103
1921	55,100	25,829	1,810	1,423	5,622	940	5,390	7,352	5,341	926
1922	56,920	28,965	883	1,284	7,130	2,388	5,051	5,230	5,482	324
1923	50,286	26,768	331	949	8,826	282	4,587	5,799	1,379	565
1924	49,813	21,824	1,111	553	8,638	1,242	3,229	9,822	689	1,281
1925	53,120	20,731	921	1,082	10,698	1,713	5,254	7,814	2,906	1,238

LIVESTOCK

Table 3 shows the livestock on the Belle Fourche reclamation project at the close of each year from 1913 to 1925, inclusive, the figures being obtained from the United States Bureau of Reclamation.

There was a decrease in numbers of all livestock in 1925 with the exception of dairy cows and fowls, which show slight increases over the numbers reported in previous years. The number of hogs reported in 1925 is the lowest since 1913. This was probably due to the high price of all grain feeds and the low price of hogs, particularly feeder pigs, which in past years have always sold at a premium, but in 1924 sold for less than fat hogs. The number of fowls reported in 1925 is the largest on record. Sheep show a decrease in 1925, as compared with 1923, but they are now much better distributed among the project farms. As a whole, the number of livestock and their values have remained fairly constant since 1919.

TABLE 3.— *Livestock on the Belle Fourche reclamation project at the close of each year for the 13-year period, 1913–1925*

Item	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925
Horses	2,490	2,848	3,135	3,514	3,734	3,877	4,238	3,608	[1]3,890	[1]3,418	[1]3,036	[1]3,099	[1]2,736
Mules	89	59	65	86	88	97	80	100					
Cattle:													
Beef	[1]2,758	2,514	5,524	8,178	6,616	4,801	8,806	3,751	5,390	4,907	3,507	2,415	3,277
Dairy		1,578	2,200	2,870	2,912	3,330	2,421	2,969	3,870	3,778	4,138	4,509	3,714
Sheep	12,872	25,740	26,210	32,152	36,459	35,607	75,398	34,781	48,510	40,028	55,233	45,350	46,461
Hogs	4,636	11,988	14,798	13,631	10,946	9,007	19,837	11,037	13,260	12,792	16,064	7,979	6,141
Fowls	23,125	29,186	21,315	27,094	24,028	18,975	20,699	20,584	26,560	33,171	32,549	32,706	35,730
Bees (hives)	139	129	326	541	541	852	900	243	510	685	685	665	855

[1] Not segregated.

Table 4 shows the number of carloads of cattle, sheep, hogs, and horses shipped from the four project towns during the years 1916 to 1925, inclusive. These figures were obtained from the office of the Chicago & Northwestern Railway Co., Deadwood, S. Dak.

The total number of carloads of all stock shipped out of the four project towns in 1925 was 1,565. The livestock shipments show a steady increase since 1921, when only 1,083 cars were shipped. In addition to the livestock shipments there were 82 carloads of wheat, 97 carloads of alfalfa hay, 39 carloads of cucumber pickles, 72 carloads of wool totaling more than 2,000,000 pounds, and 22,591 cans of cream. The wool and cream, however, were not all from project lands.

TABLE 4.—*Carload lots of livestock shipped from four shipping points on the Belle Fourche reclamation project, 1916–1925*

Year	Newell				Belle Fourche				Nisland				Fruitdale				Total				All stock
	Cattle	Sheep	Hogs	Horses	Cattle	Sheep	Hogs	Horses	Cattle	Sheep	Hogs	Horses	Cattle	Sheep	Hogs	Horses	Cattle	Sheep	Hogs	Horses	
1916	162	118	81	11	406	231	50	84	28	12	43	2	28	10	19	2	624	371	193	99	1,287
1917	233	131	77	5	760	216	35	98	92	39	29	1	72	35	13	7	1,157	421	154	111	1,843
1918	202	56	48	11	641	174	15	94	51	19	17	24	27	24	3	0	921	273	83	129	1,406
1919	208	87	79	89	1,364	318	36	281	28	22	30	1	17	24	3	0	1,617	451	148	371	2,587
1920	190	91	79	37	340	164	25	37	25	32	13	1	22	33	7	1	577	320	124	76	1,097
1921	72	135	92	3	354	263	28	14	18	42	24	1	16	19	2	0	460	459	146	18	1,083
1922	134	180	77	9	378	188	13	9	57	33	14	2	27	11	7	1	596	412	111	21	1,140
1923	157	151	132	30	468	316	21	31	30	36	39	4	21	7	8	0	676	510	200	65	1,451
1924	171	202	133	15	418	269	58	5	50	63	49	0	41	24	11	0	680	558	251	20	1,509
1925	131	172	54	16	649	246	78	34	69	31	32	2	35	9	7	0	884	458	171	52	1,565

ROTATION EXPERIMENTS WITH IRRIGATED CROPS[1]

The rotation experiments now occupy 129 plots of one-fourth acre each and three plots of one-half acre each, a total of 132 plots in field A (see figs. 1, 2, and 3). These experiments were started in 1912 and with the season of 1925 completed their fourteenth year. As time progresses it becomes possible to see in the results obtained some facts which may be useful to persons engaged in crop production under similar conditions. By crop rotations is meant the growing of

[1] For a detailed list of these experiments, see AUNE, BEYER. THE WORK OF THE BELLE FOURCHE RECLAMATION PROJECT EXPERIMENT FARM IN 1917. U. S. Dept. Agri., Bur. Plant Indus., W. I. A. Circ. 24, 31 pp., illus. 1918.

crops in a fixed order of sequence. The purpose of these experiments is to study the effect of crop sequence, the value of manure and of alfalfa, and the comparison of rotation of crops with continuous cropping.

Table 5 shows the maximum, minimum, and average yields of all the crops in the irrigated rotations at the Belle Fourche Field Station in 1925, compared with the average yields of the same crops for the preceding 13 years.

TABLE 5.—*Maximum, minimum, and average acre yields in 1925 of all crops in the irrigated rotations at the Belle Fourche Field Station, compared with the average yields of the same crops for the 13 preceding years*

[The yields of alfalfa hay, clover hay, and sugar beets are shown in tons; of all the other crops in bushels]

Crop	Number of plots	Acre yield, 1925			Average acre yield											
		Maximum	Minimum	Average	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924
Alfalfa hay	31	6.14	1.2	3.7	----	2.6	3.0	3.2	3.4	3.0	3.3	3.3	2.7	3.0	3.0	2.2	2.3
Sugar beets	22	22.7	6.3	13.5	7.6	7.8	11.6	9.2	7.1	12.3	10.2	(1)	7.9	10.0	13.3	12.6	10.2
Corn	8	50.5	28.5	40.3	28.7	33.4	44.7	29.9	39.5	42.9	40.0	37.1	32.1	40.9	38.0	45.1	27.8
Wheat:																	
Winter	3	18.7	5.1	9.7	----	11.3	22.9	27.2	11.9	16.9	21.7	10.7	4.0	11.0	8.8	11.1	17.1
Spring	7	43.5	1.7	12.2	22.1	19.9	25.7	20.9	10.0	27.8	25.0	15.8	9.8	10.9	19.0	7.3	8.9
Oats	26	90.4	12.8	59.8	51.9	39.0	78.8	92.1	54.7	59.2	73.0	41.9	27.3	41.9	51.2	54.9	57.1
Barley	3	58.8	19.4	35.8	28.0	14.8	31.7	51.2	24.4	27.0	21.8	14.4	17.7	14.8	21.3	22.3	30.7
Flax	4	10.8	3.2	7.6	13.6	13.4	14.8	15.1	7.1	14.6	17.7	7.3	8.0	11.9	12.7	12.2	9.1
Potatoes	18	299.3	134.7	205.7	45.5	112.5	105.9	116.8	153.8	148.7	164.3	60.7	(2)	152.8	158.2	104.2	185.2
Clover:																	
Hay	2	1.3	1.0	1.1	----	-----	.4	1.2	.7	-----	1.8	2.1	1.6	.7	.5	-----	.3
Seed	2	------	-----	2.0	----	-----	-----	1.8	2.1	-----	1.0	.5	-----	.9	.2	-----	.6

[1] In 1919 the beet crop was a total failure due to lack of moisture to germinate the seed.
[2] The potato crop in 1920 was a failure because of poor seed.

With the exception of alfalfa, each crop is planted at the same time on the various plots. The same variety of seed was used on all plots, and the cultural treatment was the same, so the difference in yield must be due to the differences in the plots. These differences between plots may be due in part to soil variation and in part to the effect of the preceding crop (crop sequence) or to the application of manure.

ALFALFA

The average yield of alfalfa shown in Table 5 included the records of all the plots in the rotations. The maximum yield of alfalfa in 1925 was 6.14 tons. Of the plots 2 or more years old, the minimum yield in 1925 was 3.14 and the average was 4.55 tons per acre. The alfalfa in 1923 and 1924 was damaged to some extent by grasshoppers, particularly new stands that were fall seeded. Good stands were obtained on spring-seeded alfalfa planted early without a nurse crop. Although the yields of hay were materially reduced by the grasshoppers, the stands were satisfactory. During a grasshopper siege about the only way that a stand can be obtained is to sow the alfalfa alone early in the spring. This will give it a chance to get started before the insects are of sufficient size to cause much damage. Table 6 shows the comparative yields in 1925 of alfalfa plots in the irrigated rotations grouped as to age and time of seeding.

TABLE 6.—*Comparison of yields of alfalfa in the irrigated rotations at the Belle Fourche Field Station in 1925*

Alfalfa crop	Number of plots	Average acre yield (tons)			
		First cutting	Second cutting	Third cutting	Total for season
First year, fall seeded	7	0.61	1.11	1.20	2.92
First year, spring seeded	5	----------	.86	.78	1.64
Second year, fall seeded	7	1.24	1.65	1.53	4.42
Second year, spring seeded	5	1.20	1.71	1.44	4.35
Third year	4	1.70	1.89	1.53	5.12
Fourteenth year, continuous	2	.92	1.41	1.24	3.57
Fourteenth year, continuous, manured	1	1.88	2.22	2.04	6.14

SUGAR BEETS[2]

Table 7 shows the yield of beets following stated crops in the irrigated rotations in 1925.

TABLE 7.—*Yields of sugar beets following stated crops in the irrigated rotations at the Belle Fourche Field Station in 1925*

[Yields from plots receiving manure on the crop immediately preceding beets are marked with an asterisk (*)]

Rotation	Acre yield of beets (tons)							
	After potatoes	After oats	After oats, manured	After wheat	After clover	After beets	After alfalfa	After corn, sheeped
No. 2						7.75		
No. 2a						9.50		
No. 18				9.91				
No. 20	13.69							
No. 21	*19.08							
No. 22		15.92						
No. 23			19.86					
No. 30		8.35						
No. 30a		10.04						
No. 31			14.34					
No. 32		9.04						
No. 34	17.42							
No. 35	*20.70							
No. 40	14.05							
No. 42		10.62						
No. 46							9.77	
No. 60		12.96						
No. 61			17.29					
No. 62		10.77						
No. 64	16.44							
No. 66					6.30			
No. 71								22.66
Number of plots	6	7	3	1	1	2	1	1
Average	16.90	11.10	17.16	9.91	6.30	8.63	9.77	22.66

The maximum yield of 22.66 tons was obtained in a 6-year rotation, with three years of alfalfa and one year each of corn, beets, and oats. The third-year alfalfa was pastured with sheep, and the corn was harvested with lambs. The minimum yield of 6.3 tons per acre came from a 6-year rotation where the beets followed red clover, and the average yield of all of the plots was 13.5 tons per acre. As in previous years, the best results were obtained in rotations where the beets followed a cultivated crop and manure. The effect of a preceding crop

[2] For a detailed list of rotations with sugar beets and other crops, see AUNE, B. WORK OF THE BELLE FOURCHE RECLAMATION PROJECT EXPERIMENT FARM FROM 1919 TO 1922, INCLUSIVE. U. S. Dept. Agr. Circ. 339, 48 pp., illus. 1925.

on the yield of beets is as large a factor as the application of manure alone after a crop that is not cultivated. This can be shown by comparing some of the rotations in Table 7.

Rotations 30, 31, 34, and 35 were 3-year rotations of oats, beets, and potatoes. In rotations 30 and 31 the beets followed oats. Manure was applied at the rate of 12 tons per acre after the oats had been harvested in rotations 31 and 35. The acre yield of beets in rotation 31, where beets followed oats manured, was 14.34 tons, and in rotation 34, where beets followed potatoes and no manure, 17.42 tons. In comparing rotations 31 and 35 there is a difference of 6.36 tons per acre in favor of beets following potatoes. In the comparison of 7 rotations where beets followed another cultivated crop (the average yield being 17.7 tons per acre) and 13 rotations where beets followed grain, red clover, and alfalfa (the average yield being 11.9 tons), there is a difference of 5.8 tons per acre in favor of beets following the cultivated crop. Comparing 4 rotations where beets followed potatoes without manure (the average yield being 15.4 tons per acre) with 10 rotations where beets followed grain, red clover, and alfalfa without manure (the average yield being 10.46 tons per acre), there is a difference of 5 tons per acre in favor of the cultivated crop.

To grow sugar beets in the heavy gumbo soils of the Belle Fourche project requires a sequence where beets follow a cultivated crop, and to obtain good stands it is absolutely necessary that the land be fall plowed. A spacing of 12 inches in the row has been found to be the most satisfactory. Wider spacing does not seem to increase the sizs of the beets on the heavy gumbo soil. Previous to harvesting the beets, samples from each plot were sent to the Great Western Sugar Co., Scottsbluff, Nebr., for sugar analysis. This test in 1925 showed a maximum sugar content of 19.5 per cent, a minimum of 16.3 per cent, and an average for all plots of 18.1 per cent. The average sugar content for the last 14 years was 18.5 per cent.

TABLE 8.—*Yields of corn following stated crops, in the irrigated rotations at the Belle Fourche Field Station in 1925*

[The average yields for each rotation, 1912–1925, are given for comparison]

Rotation	Acre yield of corn (bushels)										Number of years
	Pastured (yield estimated)		After sweet clover	After alfalfa	After barley	After oats	After corn (continuous)	After potatoes	After beets	Average for each rotation, 1912–1925	
	After alfalfa	After corn									
No. 6							28.5			28.5	13
No. 6a							47.0			41.3	12
No. 16						39.5				36.1	14
No. 26								43.4		38.0	14
No. 32									34.6	36.6	14
No. 37			50.5							47.2	3
No. 62				39.8						38.3	14
No. 66					38.9					40.6	14
No. 65	68.9									50.1	14
No. 69a	73.9									50.7	11
No. 69b		62.6								50.8	11
No. 71	45.1									49.1	10
Number of plots	3	1	1	1	1	1	2	1	1		
Average	62.6	62.6	50.5	39.8	38.9	39.5	37.7	43.4	34.6	42.2	

CORN

In the irrigated rotation experiments corn was grown in 11 different rotations one of which included two plots of corn. Rotations 6 and 6a were continuously cropped. No. 16 was a 2-year rotation of oats and corn; No. 26, corn and potatoes. Nos. 32 and 37 were 3-year rotations, No. 32 being oats, beets, and corn, and No. 37 being sweet clover pastured, corn, and barley. No. 66 was a 6-year rotation of winter wheat, red clover, flax, barley, and corn. Nos. 65, 69, and 71 were 6-year rotations with three years of alfalfa, the third year pastured. The corn following the alfalfa in these rotations was pastured with hogs or lambs. Table 8 shows the yield of corn following certain crops in 1925 compared with the average yield for each rotation from 1912 to 1925, inclusive.

The average yield of the 12 plots of corn for 1925 was 47.7 bushels per acre, or 5.5 bushels higher than the average yield for the period 1912 to 1925. This average differs from that given for corn yields in Table 5, because the yields given in Table 8 include those from four plots in three rotations where the corn crop is harvested with hogs or sheep and the yields are estimated. The yields from the first eight plots reported in Table 8 are the same as those reported in Table 5. The average of these for 1925 was 40.3 bushels per acre, which is 2 bushels higher than the average yield of these eight rotations for the period 1912 to 1925.

Corn is well adapted as a grain crop under irrigation on the Belle Fourche project. For the best results, corn should follow alfalfa or sweet clover in a rotation. It is also a good preparation for crops that follow, such as small grain, sugar beets, or seeding back to alfalfa.

To insure a good stand, land for corn should be fall plowed. Early planting is the best, and if good seed is used, planting from May 1 to 15 is better than at a later date. Corn may be either rowed or checked. When rowed the planter plate should be set so as to have a plant every 10 to 14 inches in the row and when checked three or four in the hill. Clean cultivation should always be practiced. Frequent irrigations are better than irrigations long delayed, and water should be applied so as to keep the corn in good growing condition at all times. Varieties that are known to ripen in the locality should be used. Of the varieties tested at the station the Payne White Dent, a selection from Rustler White Dent, has given the best results.

OATS[3]

Table 9 shows the yield of oats following stated crops in the irrigated rotations in 1925. This table shows that there were marked differences in yield of oats in the different rotations, though the preceding crop was the same. Thus oats after wheat in rotation 28 gave 12.8 bushels per acre, while oats after wheat in rotation 48 gave 89.4 bushels per acre. The difference between the two rotations is that No. 48 includes 2 years of alfalfa, while No. 28 does not. The average yield of the 26 plots of oats in 1925 was 59.8 bushels per acre. Of these 26 plots 15 were grown in rotations including alfalfa or in which manure was applied to one of the crops in the rotation or in

[3] See footnote 2, p. 9.

which there was a combination of these treatments. The average acre yield of these 15 plots was 69.1 bushels, while the average yield of the remaining 11 plots grown in rotations without alfalfa or manure was 47 bushels.

TABLE 9.—*Yields of oats following stated crops in the irrigated rotations at the Belle Fourche Field Station in 1925*

[In each rotation marked with a n asterisk (*) barnyard manure was applied to the oat stubble at the rate of 1 2 tons per acre and plowed under in the fall]

Rotation	Acre yield of oats (bushels)						
	After oats	After corn	After beets	After potatoes	After wheat	After alfalfa	After flax
No. 1	14.9						
No. 1a	46.4						
No. 16		55.1					
No. 22			61.6				
No. 23*			58.3				
No. 24				63.6			
No. 25*				75.8			
No. 27				63.5			
No. 28					12.8		
No. 30				62.1			
No. 30a				56.0			
No. 31*				76.3			
No. 32		38.4					
No. 34			42.5				
No. 35*			44.4				
No. 42						59.3	
No. 44				90.4			
No. 46			79.0				
No. 48					89.4		
No. 60				66.5			
No. 61*				60.9			
No. 62		57.4					
No. 64			56.4				
No. 65							66.0
No. 69		86.4					
No. 71			70.6				
Number of plots	2	4	7	9	2	1	1
Average	30.6	59.3	59.0	68.3	51.1	59.3	66.0

WHEAT

Spring wheat was grown in seven rotations, and in five of these wheat followed another small grain. In the other two the wheat followed beets in a 2-year rotation and alfalfa in a 4-year rotation (2 years of alfalfa and 1 year each of wheat and oats). The maximum acre yield of 43.5 bushels in 1925 came from the rotation where the wheat followed alfalfa. The minimum yield of 1.7 bushels was obtained from the 2-year rotation of wheat and oats. The average yield of all the rotations was 12.2 bushels per acre. In the five rotations where wheat followed another small grain, the wild oats took possession of the land, which accounts to some extent for the low yields. The average acre yield of wheat following alfalfa for the 14-year period from 1912 to 1925, inclusive, was 26.4 bushels; of wheat following beets, 26.2 bushels; and of wheat following another small grain, 13.2 bushels. The average acre yield of spring wheat in all rotations for this period was 18.4 bushels, as compared with that of winter wheat, 14.1 bushels.

From these observations, wheat, even when grown under the most favorable conditions, can not be recommended as an irrigated crop on the Belle Fourche project.

POTATOES[4]

Table 10 shows the yields of potatoes with the preceding crop in the irrigated rotation in 1925.

The maximum yield of 299.3 bushels per acre was obtained in a 4-year rotation, 2 years of alfalfa and 1 year each of potatoes and oats. The minimum acre yield of 134.7 bushels came from a 2-year rotation of potatoes and beets, and the average of all rotations was 205.6 bushels. The average yield for all the rotations for the 14-year period from 1912 to 1925, inclusive, was 133.5 bushels per acre. The yield of potatoes in 1925 was the most satisfactory to date, the average yield being 72 bushels higher than the average yield for the last 14 years. Potatoes which follow a cultivated crop seem to have a tendency toward lower yields, and particularly so in rotations without manure.

Comparing two rotations, Nos. 20 and 21, beets and potatoes, one receiving manure at the rate of 12 tons per acre and the other without manure, the difference in yield was 108 bushels per acre in favor of the manured rotation.

TABLE 10.—*Yields of potatoes after stated crops in the irrigated rotations at the Belle Fourche Field Station in 1925*

Rotation	Acre yield of potatoes (bushels)							
	After potatoes	After beets	After beets, manured	After oats	After oats, manured	After oats and rye	After corn	After alfalfa
No. 4	164.7							
No. 4a	214.0							
No. 20		134.7						
No. 21			242.7					
No. 24				185.8				
No. 25					237.3			
No. 26							224.3	
No. 27						150.7		
No. 30		189.3						
No. 30a		180.0						
No. 31			226.7					
No. 34				195.0				
No. 35					295.3			
No. 40								182.0
No. 44								299.3
No. 60								222.0
No. 61								219.3
No. 64								139.3
Number of plots	2	3	2	2	2	1	1	5
Average	189.4	168.0	234.7	190.4	266.3	150.7	224.3	212.4

Comparing two similar 3-year rotations, 30 and 31 (potatoes, oats, and beets), the difference in acre yield was 37.4 bushels in favor of the rotations receiving manure.

Comparing rotations 24 and 25, where the potatoes followed oats, the difference was 51.5 bushels in favor of the rotation receiving manure.

Comparing two 3-year rotations, 34 and 35, where the potatoes followed oats, the difference in acre yield was 100.3 bushels in favor of the rotation receiving manure.

[4] For reference to a detailed list of rotations containing potatoes, see footnote 2, p. 9.

The yield of potatoes following alfalfa was somewhat better than in previous years. The maximum yield came from a plot of potatoes following alfalfa, but one of these plots was also close to the minimum yield. The average acre yield of the five plots of potatoes following alfalfa was 212.4 bushels, which is somewhat better than potatoes following oats, but not so good as where potatoes followed oats with manure.

An important factor in the growing of potatoes is the use of seed that is free from disease. This can probably be accomplished with the least expense by planting a seed patch each year with certified seed of known origin and free from disease.

RED CLOVER

Red clover has been grown in the irrigated rotations since 1912. It was included as a crop with the idea of growing the first crop for hay and the second crop for seed. In no year has the yield of hay been equal to alfalfa on similar ground. The yield of seed from the second cutting has been discouraging, and red clover as a field crop on the Belle Fourche project can not be recommended.

BARLEY

Barley is grown under three different cropping systems in the irrigated rotations. One system is that of continuous cropping; in another barley follows flax in a 6-year rotation; and the third is barley following corn. The corn in turn follows sweet clover in a 3-year rotation, the sweet clover being pastured with dairy cows. The maximum acre yield of 58.8 bushels was obtained in 1925 in the rotation where the barley followed corn, and the minimum of 19.4 bushels came from the continuously cropped plot. The average of the three plots was 35.8 bushels. The acre yield of barley in the 6-year rotation where the barley followed flax was 29.3 bushels, and the average yield of the same rotation for the last 14 years was 29.7 bushels. The average for the last three years of the barley in the rotation where it followed corn was 47.9 bushels.

Satisfactory yields of barley are obtained where the planting is on good ground and following a cultivated crop. When a nurse crop is to be used in seeding alfalfa, barley serves the purpose better than either wheat or oats. Under proper management barley is one of the most profitable small grains for feed that can be grown locally under irrigation.

SUMMARY OF OBSERVATIONS OF THE IRRIGATED ROTATION EXPERIMENTS

The observations made on the crops in the irrigated rotations in 1923, 1924, and 1925 are similar to those of previous years and are principally as here given.

Crops following alfalfa have shown no marked increase in yield except when the alfalfa is pastured by sheep or hogs. The application of manure has given a marked increase in the yields of sugar beets, alfalfa, and potatoes and a slight increase in the yield of grain. Sugar beets following a cultivated crop have given fairly uniformly good results, and sugar beets following a grain crop without manure, or after red clover or alfalfa, have given uniformly poor results. Potatoes in rotations which include manure or alfalfa have given better yields than without these treatments. The same is true of

corn. Harvesting certain field crops by pasturing with livestock results in higher net returns per acre than harvesting in the usual way and gives a marked increase in yield on the crops that follow.

Before grasshoppers became prevalent on the project the seeding of alfalfa after grain had been harvested in the late summer gave the most satisfactory results. The stands were better and the production higher the first year after planting. During a grasshopper siege the best method is to plant the alfalfa alone early in the spring without a nurse crop. Early-seeded spring grains have given better results in quality and yield than late-seeded spring grains. Fall plowing is absolutely necessary to obtain good stands of sugar beets and corn.

From the observations made on the irrigated rotations the advantages in favor of a crop rotation may well be mentioned. The increase in yields, reduction in risks (including climatic conditions, plant disease, insect pests, and marketing), and better distribution of labor and more economical production are some of the most important of these advantages.

In planning a rotation applicable to the Belle Fourche project and adjacent areas the following factors may be kept in mind. The farm must be divided into as many fields as there are years in a rotation. A legume crop, such as alfalfa or sweet clover, should be included, and the last year before this is plowed for the following crop it should be pastured with livestock if possible. The crops in a rotation should be so planned that the previous crop is a preparation for the crop to follow. Manure should be applied at least once during the rotation, and the rotation should include a cultivated crop.

The length of a rotation and the crops included should be planned with a view to supplying feed for livestock throughout the year.

The following rotations are suggested: Alfalfa, three or four years, the last year being pastured when possible, followed by two years of corn, of which one may be pastured. Where sugar beets can be grown, follow the corn with beets, apply manure after the first year of corn, and follow the beets with barley in which alfalfa is seeded. In addition to the main rotation, a 3-year or 4-year rotation is also advisable, consisting of corn for silage, small grain or sugar beets, followed by barley seeded to sweet clover, the sweet clover being pastured with dairy cows or sheep. If a 4-year rotation is used, pasture the corn with lambs or hogs.

It can not be stated definitely just what yields are necessary to cover the production costs, as these costs vary from year to year like crop values. However, by taking the average production cost and average farm prices for a period of years, a fairly accurate computation may be made. From deductions made in this manner, and allowing $10 per acre for land rental, it may be stated that certain minimum yields are necessary to cover production charges. The required minimum acre yields are:

Alfalfa, 3 tons; barley, 40 bushels; sugar beets, 10 tons; corn, 40 bushels; oats, 60 bushels; potatoes, 125 bushels; wheat, 30 bushels.

Taking the average yield for the last 14 years, it is found that in 15 rotations where alfalfa was grown, only 5 produced 3 or more tons per acre; in 3 rotations containing barley, only 1 produced more than 40 bushels per acre; in 22 rotations where beets are grown, 11 have produced 10 or more tons per acre, and in these rotations the beets

follow a cultivated crop or manure with only one exception; in 11 rotations in which corn is grown, 6 have produced 40 or more bushels per acre; in 26 rotations in which oats were grown, only 10 have produced 60 bushels per acre; in 18 rotations growing potatoes, only 5 have produced 125 bushels per acre; in 7 rotations in which wheat was grown the yields have averaged lower than 30 bushels per acre.

In rotations that yielded enough to pay the production costs the yields are either remaining constant or increasing as time goes on, while in the rotations yielding less than the production costs the yields are decreasing.

A balanced agricultural program requires that a definite and permanent plan be established and carried out. This applies not only to crop production but also to the livestock industries.

SMALL-GRAIN AND OTHER VARIETAL EXPERIMENTS[5]

WINTER WHEAT AND RYE

Winter wheat and rye were sown on triplicated fiftieth-acre plots on corn ground which was irrigated, double disked, and harrowed previous to seeding. The planting was done with a disk drill at the rate of 5 pecks per acre on September 22, 1922, September 27, 1923, and September 9, 1924. The yields for these years are shown in Table 11.

All winter grains were irrigated twice in 1923 and 1924 and three times in 1925. In past years winter wheat has shown a higher yield over a period of years than winter rye, and the same result was obtained in this 3-year period. The low yields in 1923 were due to excessive rains and hot weather in July.

TABLE 11.—*Annual and average yields of rye and of winter and spring wheat at the Belle Fourche Field Station in 1923, 1924, and 1925*

Crop	C. I. No.[1]	Acre yield (bushels)			
		1923	1924	1925	Average
Winter rye	137	9.5	19.0	19.6	16.0
Turkey (Red winter wheat)	3,055	7.0	36.8	18.9	20.9
Kubanka (spring wheat)	1,440	15.9	21.4	23.9	20.4

[1] Accession number of the Office of Cereal Crops and Diseases.

SPRING WHEAT

Spring wheat was grown on corn ground in 1920, fall-plowed alfalfa ground in 1921, potato ground in 1922, and corn ground in 1923, 1924, and 1925. The wheat was seeded at the rate of 5 pecks per acre in triplicated fiftieth-acre plots. Table 12 shows the annual and average yields of spring wheat grown at the Belle Fourche Field Station during the 6-year period from 1920 to 1925, inclusive.

In 1920 the Marquis wheat was entirely destroyed by rust. The low yields in 1921 were probably due to the unfavorable growing con-

[5] For experiments with cereals on the Belle Fourche Experiment Farm, see MARTIN, J. H. EXPERIMENTS WITH CEREALS ON THE BELLE FOURCHE EXPERIMENT FARM. U. S. Dept. Agr. Bul. 1039, 72 pp., illus. 1922.

ditions in the spring and early summer which resulted in poor stands. The Kota, a common wheat of the hard red spring class, was first grown at the station in 1921. This variety has given the best yields during the five years that it has been included in the test. Kota is resistant to the principal forms of black-stem rust and will outyield Marquis in unfavorable years. In milling and baking tests Kota compares favorably with the results obtained from Marquis. In 1925 three new varieties were tried—Ceres, Quality, and Reliance. Ceres and Reliance compared favorably with the other varieties in 1925.

TABLE 12.—*Yields of wheat varieties under irrigation at the Belle Fourche Field Station, 1920–1925*

Variety	Acre yield of wheat (bushels)						
	1920	1921	1922	1923	1924	1925	Average
Acme	19.1	11.1	15.7	12.5	21.7	23.6	17.3
Kubanka	19.1	9.4	19.2	15.9	21.4	23.9	18.1
Marquis	[1]0	7.2	16.8	11.5	26.1	26.4	14.7
Power		8.4	14.6	12.4	24.7	21.8	16.4
Kota		9.8	19.7	17.7	26.1	22.6	19.2
Haynes bluestem			15.0	10.3	26.9	22.0	18.5
Ceres						23.9	
Quality						19.7	
Reliance						27.1	

[1] The total failure of Marquis in 1920 was due to rust.

OATS

The oat varieties were planted on disked corn ground in 1920, on fall-plowed alfalfa ground in 1921, on disked potato ground in 1922 and 1923, and on disked corn ground in 1925. The oats were seeded at the rate of 10 pecks per acre in triplicated fiftieth-acre plots. The yields of the oat varieties under irrigation for the last six years are shown in Table 13.

TABLE 13.—*Yields of oat varieties under irrigation at the Belle Fourche Field Station, 1920–1925*

Variety	Acre yield of oats (bushels)						
	1920	1921	1922	1923	1924	1925	Average
Sixty-Day	38.0	16.2	36.0	37.3	67.8	53.1	41.4
Swedish Select	37.2	29.9	43.5	37.0	70.6	50.5	44.8
Canadian		19.9	39.8	18.8	66.8	56.2	40.3
Silvermine	37.7	27.2	45.8	32.6	70.2	55.7	44.9
White Russian	24.7	32.1	45.8	25.8	66.3	49.5	40.7
Hull-less[1]					46.9	39.6	
Victory						60.9	
Golden Rain						53.6	
Markton						56.3	

[1] The yield of Hull-less oats is computed on the basis of 32 pounds to the bushel.

During the 6-year period from 1920 to 1925, inclusive, the Swedish Select and Silvermine, midseason varieties, produced the highest

average yields. These two varieties are well adapted to irrigation in western South Dakota. The Sixty-Day is a good early variety but it does not yield as well under irrigation as the Swedish Select or Silvermine. The White Russian yields about the same as the Sixty-Day, but as it ripens about two weeks later it is not so desirable. The Hull-less variety was first grown in 1924 and does not compare in yield with the other varieties during the two years that it has been grown. It is also difficult to store in any quantity on account of a tendency to heat in the bin.

Three new varieties were added to the test in 1925—Victory, Golden Rain, and Markton. The Victory and Markton look like promising varieties. The Markton is smut proof and for that reason would be the most desirable variety, even though it did not yield as high as the Victory in 1925. However, it outyielded the Swedish Select by 6 bushels and the Silvermine by half a bushel.

BARLEY AND SPRING EMMER

The barley varieties and the White Spring emmer were planted on disked corn ground in 1920, on fall-plowed alfalfa ground in 1921, on disked corn ground in 1922, on disked potato ground in 1923, and on disked corn ground in 1924 and 1925. The barley was seeded at the rate of 6 pecks per acre in triplicated fiftieth-acre plots. The White Spring emmer was seeded at the rate of 8 pecks per acre in the same manner for the purpose of comparing it with barley. Table 14 shows the annual yields from 1920 to 1925, inclusive, and the average yield for the six years.

The yields of emmer in pounds of grain per acre were less than the better varieties of barley. The Trebi (C. I. No. 336), a 6-row variety, produced the highest yield and is recommended for growing under irrigation in western South Dakota. A comparison of the average acre yields of the best varieties of barley, wheat, oats, and emmer, during the 6-year period from 1920 to 1925, inclusive, shows the following results: Trebi barley, 1,890 pounds; Swedish Select oats, 1,435 pounds; Kota wheat, 1,150 pounds; White Spring emmer, 1,724 pounds. Barley yields the most feed per acre when planted on good ground and properly cared for.

Table 14.—*Yields of barley varieties compared with yields of emmer under irrigation at the Belle Fourche Field Station, 1920–1925*

Crop	Acre yield (bushels)						
	1920	1921	1922	1923	1924	1925	Average
Barley:							
Trebi	34.6	12.8	51.4	42.9	54.8	39.9	39.4
Coast		7.1	39.9	35.1	33.7	36.1	30.4
Hannchen		10.4	36.3	32.0	41.7	38.9	31.8
Chevalier	25.0	15.4	26.9	22.0	46.2	39.3	29.1
Minsturdi				34.6	38.6	31.6	34.9
Luth				24.8	26.8	26.0	25.9
Emmer (32-pound bushel)		29.1	54.7	52.9	72.0	60.9	53.9

FLAX

The flax varieties were seeded on disked corn ground in 1920 and 1922, on fall-plowed alfalfa ground in 1921, on disked corn ground in 1923, and on disked potato ground in 1924 and 1925. The flax was seeded at the rate of 40 pounds per acre in triplicated fiftieth-acre plots. Winona, a wilt-resistant variety, and Argentine No. 280, a large-seeded variety, are two of the most promising varieties. The annual yields from 1920 to 1925, inclusive, of the flax grown under irrigation and the average for the six years are shown in Table 15.

TABLE 15.—*Yields of flax varieties under irrigation at the Belle Fourche Field Station, 1920–1925*

Variety	Acre yield of flax (bushels)						
	1920	1921	1922	1923	1924	1925	Average
Damont (N. D. No. 1215)	15.2	1.4	11.9	6.3	9.8	14.1	9.8
Primost (Minn. No. 25)	14.9	4.8	12.9	7.0	12.7	12.2	10.7
N. D. R. No. 52		3.6	14.5	7.2	13.3	13.3	10.4
N. D. R. No. 114		3.2	12.9	8.8	14.9	9.5	9.9
Winona					15.2	12.2	13.7
Argentine (No. 280)					13.3	15.2	14.2
Linota (No. 244)						13.5	

Table 16.—Yields of potato varieties under irrigation at the Belle Fourche Field Station, 1922–1925

[Yields stated in bushels]

Variety	1922			1923			1924			1925			Average		
	Acre yield	Marketable		Acre yield	Marketable		Acre yield	Marketable		Acre yield	Marketable		Acre yield	Marketable	
		Per cent	Yield		Per cent	Yield		Per cent	Yield		Per cent	Yield		Per cent	Yield
Bliss Triumph:															
Certified 1922	-----	----	-----	232.2	95	220.6	177.4	97	172.1	258.8	92	238.1	222.8	95	210.3
Certified 1923	-----	----	-----	-----	----	-----	186.3	97	180.7	230.3	86	198.1	208.3	91	189.4
Certified 1924	-----	----	-----	-----	----	-----	-----	----	-----	283.8	90	255.4	283.8	90	255.4
Immature seed	-----	----	-----	-----	----	-----	190.4	93	177.1	281.3	77	216.6	235.8	85	196.8
Farm seed	241.5	84	202.6	213.5	91	194.3	145.6	97	141.2	253.8	89	225.9	213.6	90	191.0
Pearl	213.4	75	160.0	239.1	90	215.2	80.7	88	71.0	-----	----	-----	177.7	84	148.7
Greeley Pearl (certified 1923)	-----	----	-----	-----	----	-----	179.9	94	169.1	251.9	91	229.2	215.9	92	199.1
Irish Cobbler	160.3	57	91.4	272.4	86	235.7	129.7	84	109.0	253.1	83	210.1	203.9	77	161.5
Rural New Yorker	-----	----	-----	-----	----	-----	194.1	96	186.3	231.5	86	199.1	212.8	91	192.7
Green Mountain	253.3	70	177.3	265.6	84	223.1	255.5	97	247.8	237.5	75	178.1	253.0	81	206.6
Early Ohio	183.0	70	138.1	242.7	91	220.9	103.0	88	90.6	240.5	86	206.8	192.3	84	164.1
Idaho Russet	-----	----	-----	-----	----	-----	-----	----	-----	274.7	81	222.5	274.7	81	222.5

VARIETAL TESTS OF POTATOES

The potatoes in 1922 were grown on the land that had been in grain in 1921 and had been manured at the rate of 12 tons per acre and fall plowed. In 1923 potatoes were grown on alfalfa ground. This alfalfa had been used for hog pasture from 1918 to 1922, inclusive, and was fall plowed in 1922. In 1924 the potatoes were grown on land that had been in alfalfa previous to producing a grain crop in

1923. This land was manured and fall plowed after the grain was removed. In 1925 potatoes were grown on the same land as in 1923. This land was in grain in 1924, and after harvesting the grain the land was manured and fall plowed. The potatoes were grown in triplicated plots of two rows each, the rows being 42 inches apart and 132 feet long. The acre yields and the percentages of marketable tubers grown during the period from 1922 to 1925, inclusive, are shown in Table 16.

The highest yields of all varieties were obtained in 1923, when potatoes followed alfalfa pastured with hogs. In 1924 the differences in yield were probably due to disease rather than to variety. The Green Mountain shows the highest yield for the period, but it is rather late maturing for this locality. Of the earlier varieties the Bliss Triumph is one of the best and is well adapted to irrigation. The main factor determining yield is the planting of seed potatoes that are free from disease, for it has been observed that there has been a greater variation in the same variety due to disease infection than among the different varieties. In Table 16 this is shown in the case of Pearl grown locally since 1917 and the certified Pearl obtained from Greeley, Colo., in 1923.

VARIETAL TESTS OF CORN

During the period from 1922 to 1925, from 9 to 16 varieties of corn were tested each year on irrigated land. The varieties were grown in triplicated plots, two rows wide and 132 feet long, checked to 42 inches in the row and thinned to three stalks in the hill. Table 17 shows the annual and average yields of corn during the 4-year period from 1922 to 1925, inclusive. The yields are computed from the air-dry weights at 70 pounds per bushel of ear corn. The condition of the corn when harvested and the percentage of grain are also shown.

The seasons of 1922, 1923, and 1925 were favorable to the production of corn, and practically all varieties matured. The season of 1924 was very unfavorable to corn production, and only one variety matured before the first light frost occurred on September 15. At the time of husking on November 20 each variety was weighed and samples were taken to determine the loss of weight in air drying. This excess moisture at harvest time is given as the percentage of air-dry weight of corn after drying from three to four weeks in a warm dry room, when it still contained about 12 per cent of moisture. This loss is shown in columns 10 to 13 of Table 17.

The percentage of ripe corn was determined by separating the immature ears from the ripe ones and weighing the ripe corn. The percentage of shelled corn was determined by weighing the air-dry corn before and after shelling.

Of the dent varieties, the Payne White Dent shows the best yield. This variety has been grown at the Belle Fourche station since 1912. During this time it has matured practically every year, and it is one of the most promising of the varieties grown in the tests. This variety has shown itself to the best advantage in years unfavorable to corn production, such as 1924. It was originally a selection from Rustler White Dent. Of the flint varieties, the Gehu is the earliest maturing of all those tested. It yields very well and may have a place for early hogging or pasturing.

TABLE 17.—*Yields and condition of corn varieties grown under irrigation at the Belle Fourche Field Station, 1922–1925*

[The excess moisture content at husking time (columns 10-13) is given as a percentage of the air-dry weight of grain after storage for one month in a warm dry room, when it still contained about 12 per cent of moisture]

Variety	Acre yield of grain (bushels)					Acre yield of stover (tons)		
	1922	1923	1924	1925	Average	1923	1925	Average
1	2	3	4	5	6	7	8	9
Squaw	50.5	62.2	29.9	41.8	46.1	1.7	1.5	1.6
Flint:								
Gehu	35.6	45.0	36.6	34.7	38.0	2.1	1.3	1.7
Rainbow	45.9	61.9	38.6	48.2	48.6	1.6	2.0	1.8
Disco White	37.1	60.0	28.9	43.1	42.3	1.5	1.8	1.6
Yellow dent:								
North Dakota	36.1	48.7	38.6	45.0	42.1	1.5	1.2	1.3
Minnesota No. 13	37.9	56.4	29.6	47.6	42.9	1.8	1.2	1.5
Matri Jones	------	49.4	39.2	49.5	46.0	1.9	2.2	2.0
Alta	------	56.5	31.5	50.2	46.1	1.0	1.1	1.0
All Dakota	------	55.3	32.8	46.9	45.0	1.1	1.3	1.2
Early Murdock	------	57.8	28.3	------	43.0	1.8	------	1.8
Black Hills	------	35.1	29.6	45.7	36.8	1.4	1.5	1.4
Burda	------	------	37.3	50.2	43.7	------	1.2	1.2
White Cap, Soma	41.5	49.7	37.9	43.7	43.2	1.4	1.5	1.4
Hentzel, Vale	------	------	33.4	49.5	41.4	------	1.4	1.4
White dent: Payne White Dent	45.7	52.8	40.5	47.6	47.1	.9	1.2	1.0
Northwestern Dent: Huntley	34.4	49.2	42.4	42.4	41.6	1.2	1.0	1.1

Variety	Grain conditions at husking time (per cent)											
	Excess moisture content				Soft corn				Shelled corn			
	1923	1924	1925	Average	1923	1924	1925	Average	1923	1924	1925	Average
1	10	11	12	13	14	15	16	17	18	19	20	21
Squaw	24	32	17	24	5	53	5	21	73	71	77	74
Flint:												
Gehu	4	16	6	9	0	0	0	0	74	83	78	78
Rainbow	28	37	28	31	15	36	5	19	75	70	77	74
Disco White	12	38	22	24	0	37	8	15	73	63	75	70
Yellow dent:												
North Dakota	43	17	10	23	40	14	0	18	78	79	80	79
Minnesota No. 13	23	33	18	25	10	28	0	13	75	75	84	78
Matri Jones	30	21	25	25	40	7	14	20	80	80	80	80
Alta	6	24	12	14	0	13	0	4	80	80	81	80
All Dakota	11	35	17	21	5	92	0	32	77	70	81	76
Early Murdock	25	17	12	18	0	9	0	3	81	77	82	80
Black Hills	19	50	----	35	25	81	----	53	75	74	----	74
Burda	----	22	10	16	----	6	0	3	----	78	81	79
White Cap, Soma	13	25	19	19	0	13	0	4	78	80	81	80
Hentzel, Vale	----	17	12	14	----	20	7	13	----	80	80	80
White dent: Payne White Dent	14	20	12	15	0	5	0	2	80	81	82	81
Northwestern Dent: Huntley	18	16	15	16	0	3	0	1	80	80	82	81

SILAGE TESTS

Tests of silage crops have been conducted since 1917 on land that has produced a grain crop the previous year and has been fall plowed. The varieties were grown in triplicated plots of four rows each, 132 feet long and 42 inches apart. The annual yields from 1920 to 1925, inclusive, and the average yield for the six years are shown in Table 18.

The silage corn has been planted at the same time as the corn grown for grain, usually about May 15. The corn is generally harvested between September 1 and 15 and at that time is well dented, with the exception of the Red Cob. In 1923 and 1925, at the time of filling the silo, samples were taken of each variety, and the results of the drying test are also shown in Table 18.

TABLE 18.—*Yields and dry-matter content of silage crops grown under irrigation at the Belle Fourche Field Station, 1920–1925*

Crop	Acre yield (tons)							Total yield and dry-matter content compared								
								Acre yield (tons)			Air-dry matter					
											Per cent			Tons		
	1920	1921	1922	1923	1924	1925	Average	1923	1925	Average	1923	1925	Average	1923	1925	Average
Corn:																
Sweet Fodder	8.14	8.54	8.38	10.24	6.15	9.95	8.57	10.24	9.95	10.09	28	26	27	2.87	2.59	2.73
Payne White Dent	11.03	7.93	7.49	9.45	7.35	8.55	8.63	9.45	8.55	9.00	45	37	41	4.25	3.16	3.70
Red Cob	10.91	9.40	11.48	14.55	9.12	13.32	11.46	14.55	13.32	13.93	26	27	26.5	3.78	3.60	3.69
Sorgo:																
Dakota Amber	6.11	6.54	9.06	10.65	6.04	9.82	8.04	10.65	9.82	10.23	38	31	34.5	4.05	3.04	3.54
Minnesota No. 13	10.05	7.92	9.12	12.41	8.48	12.71	10.11	-----	-----	------	----	----	------	----	----	------
Sunflower:																
Mammoth Russian	16.09	11.51	8.67	-----	----	-----	12.09	12.41	12.71	12.56	28	(1)	28	3.47	(1)	3.47

[1] Original weig ht of this variety was lost.

The Red Cob corn produced the largest yield in 1923 as well as the largest average yield for the last five years, but being immature at the time of harvest it was not especially fitted for silage. The Payne White Dent produced the largest yield of dry matter per acre and also the largest quantity of grain in proportion to the leaves and stalks. Similar Payne White Dent corn that was harvested yielded at the rate of more than 50 bushels of ears per acre. Dakota Amber sorgo is practically the same in yield as Payne White Dent, but cane silage is not relished as much by livestock as corn silage, and the same is also true of the Mammoth Russian sunflower. Where corn can be grown successfully these other crops are not recommended. Silage crops should be judged by their feeding value rather than by bulk or weight. Corn varieties that have been known to mature in the particular locality should be used in preference to the so-called silage corn grown farther south.

ORCHARD PLANTINGS

The land for orchard planting was first broken from sod in 1911, planted to alfalfa in 1912, and plowed in the fall of 1915.

APPLES

In 1916 the following varieties of apples were planted in the irrigated orchard, the five last named being crabs: Wealthy, Hibernal, Longfield, Patten (*Patten Greening*), Yellow Transparent, Jewell

(*Jewell Winter*), Oldenburg (*Duchess of Oldenburg*), Ben Davis, Virginia, Minnesota, Florence, Whitney, and Transcendent. Ben Davis winterkilled the first winter. All of the other varieties were in good growing condition.

One-year-old stock was used, and a good stand was obtained the first year. One-year-old stock is preferable to older trees. As a rule, nursery-grown trees 3 or more years old are headed too high for conditions in western South Dakota, cost considerably more, and are harder to start.

The trees were planted 20 by 24 feet, but this spacing is too close; 35 to 40 feet would be better, particularly in the lighter soils. For the first six years the orchard was given clean cultivation, but this involved a good deal of labor, both for keeping weeds out and for irrigation, as the land had considerable slope. In 1922 the orchard was seeded to red clover, with the exception of a space of about 10 feet around each tree which was kept fallow. Red clover is a good cover crop, makes some return from the land until the trees come to bearing age, and adds fertility to the soil. Alfalfa would make larger returns per acre than red clover, but it is not a desirable crop to use for this purpose, as the young trees are not able to compete with alfalfa for moisture. Pruning should be commenced the first year and continued every year. Trees should be headed low, about 2½ feet; this will help to prevent sun scald.

Spraying is also an important item, particularly in the spring just after the petals have fallen. Lime-sulphur has been used for this spray—4 pounds of lime-sulphur to 50 gallons of water. If there are any insect pests later in the season, lead arsenate—1½ pounds to 50 gallons of water—has been used. Sprays should be applied under pressure of 175 to 200 pounds.

Virginia, Transcendent, and Florence crabs first came into bearing in 1920; Minnesota, 1921; Longfield, 1922; Oldenburg, 1923; Patten and Jewell, 1924. In 1924 the crab varieties averaged about 1½ boxes per tree; the Longfield averaged about 1 box per tree. Patten and Jewell produced a few apples. In 1925 the spring was unusually early and warm. On April 20 all the varieties were practically in full bloom when the temperature went down to 20° F. The crab varieties produced some fruit, but the crop was very light.

PLUMS

In 1916 the Wolf, Wyant, De Soto, and Compass varieties of plums were planted. In 1920 Sapa, Waneta, and Hanska were added. The plums were spaced 15 by 20 feet. This seems to give ample room. The plums set out in 1916 came into bearing in 1920, and those set out in 1920 came into bearing in 1924. All the varieties have survived to date. Of the plums, the Waneta seems to be the most desirable, particularly as to quality.

Hardy varieties of apples and plums can be grown successfully in western South Dakota under irrigation.

DRY-LAND ORCHARD

In 1913 the same varieties of apples heretofore listed were planted on dry land, with Malinda in addition. These trees, spaced 33 by 33 feet apart, have been given continuous clean cultivation. They

came into bearing at about the same age as the irrigated orchard, and up to date they have shown no effect of drought.

The same varieties of plums were also set out in 1913 and have since been in good condition. The difference between the dry and irrigated trees is that the fruit in dry years is considerably smaller in the dry-land orchard. To grow fruit trees successfully on dry land requires a spacing of at least 33 feet each way and absolutely clean cultivation.

UTILIZATION OF CROPS WITH LIVESTOCK

PASTURING SWEET CLOVER WITH DAIRY COWS

Rotation 37 covers a 3-year period—corn, barley seeded to sweet clover, and sweet clover pastured with dairy cows. This rotation was started in 1922, but the sweet-clover pasture was not available for pasturing until 1923. When the cows were first turned into the sweet-clover pasture they did not take to it very readily. Although the quantity of milk varied but little when changing to sweet clover from the grass pastures, the cows lost in weight. There was also a severe case of bloat when they were first turned on the sweet clover in 1923. Figuring the results on an acre basis, the sweet-clover pasture furnished pasture for two cows from May 24 to August 14, a pasturing period of 82 days. The clover made very little growth after the last-named date. The cows used in this test were good high-grade Holsteins, and the milk produced during the pasturing period was 4,070 pounds, yielding 180 pounds of butterfat.

The sweet clover that had been planted with the barley in 1923 furnished 25 days of pasturing for two cows beginning September 13, during which time they produced 1,000 pounds of milk containing 45 pounds of butterfat. There was an excellent stand of sweet clover in the fall of 1923, but for some reason this was badly winterkilled, and in the spring of 1924 there was probably not more than one-fourth of a stand. It was reseeded April 18, but no pasture was available until June 23. Computing the results obtained in 1924 on an acre basis, the sweet clover furnished pasture for two cows from June 23 to August 17, a period of 50 days, producing 1,900 pounds of milk which yielded 90 pounds of butterfat. Where the sweet clover was seeded with the barley as a nurse crop, good stands were obtained in 1924, but by mistake this plot was mowed and did not afford any pasture that season. In 1925 the cows were first turned in on May 21, and on an acre basis the sweet clover furnished pasture from May 21 to August 27 for two cows with an additional pasture period of 32 days for one more cow, giving a total of 228 pasturing days for one cow. The total production of milk was 4,700 pounds which yielded 180 pounds of butterfat. A good stand of sweet clover was obtained in the plot seeded to barley and sweet clover, and this furnished pasture for 40 days commencing August 31 for one cow giving 618 pounds of milk which yielded 24 pounds of butterfat.

As previously stated, there was no material change in the milk flow when cows were changed from sweet clover to mixed-grass pastures, but the cows lost considerable weight while on sweet-clover pasture. This loss in weight could probably be remedied by feeding a supplemental grain ration when pasturing sweet clover.

From the three years results it appears that sweet-clover pasture can be used to advantage on the heavy gumbo soils of the Belle Fourche project. Like all other irrigated pastures, the sweet-clover pasture should be divided into two lots so that the stock can be kept off during irrigation. By this alternation a much better growth is obtained than when the whole area is pastured continuously. Handled in this manner, 1 acre of sweet clover should furnish pasture for at least two cows for a period of 110 days on the year-old sweet clover and about 40 days on spring-seeded sweet clover.

PASTURING ALFALFA, CORN, AND BEET TOPS WITH SHEEP

Rotation 71 covers a 6-year period, three years of alfalfa and one year each of corn, beets, and oats. The third year of alfalfa was pastured with ewes and lambs, and the corn was harvested by the lambs. During the years from 1916 to 1923, inclusive, the ewes were removed about the latter part of July and the lambs pastured for the remainder of the season. During the season of 1924 and 1925, however, the lambs were taken off the alfalfa and sold about the first week in August, as by that time they had reached a weight of 85 pounds, which is considered a good marketing weight. The ewes were retained on the alfalfa pasture until the first part of October. This method seems to be more desirable than the system formerly used, and the number of pasturing days remains about the same. On alfalfa pasture yielding about 4 tons per acre, the carrying capacity per acre would be at the rate of about 8 ewes from May 20 to October 1 and 12 lambs from May 20 to August 1. Table 19 shows the results of pasturing ewes and their lambs on alfalfa on an acre basis from 1916 to 1925.

TABLE 19.—*Results of pasturing ewes and lambs on alfalfa at the Belle Fourche Field Station, 1916–1925*

Year	Number of—		Average initial weight (pounds)		Days pastured		Average gain of lambs (pounds)	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs	Daily	Per acre
1916	12	12	------	------	87	87	0.23	240
1917	8	16	128	35	80	80	.30	380
1918	8	12	140	33	82	112	.30	405
1919	8	12	120	30	74	74	.57	512
1920	8	12	127	46	59	103	.45	560
1921	8	12	153	49	46	106	.41	528
1922	8	12	136	41	56	101	.30	372
1923	8	12	137	48	70	105	.30	390
1924	8	12	114	52	126	56	.49	328
1925	8	12	146	40	141	78	.51	480
Maximum	------	------	153	52	141	112	.57	560
Minimum	------	------	114	30	46	56	.23	240
Average	------	------	133	42	82	90	.39	419

The average daily gain for this period was 0.39 pound per lamb, and the average total gain per acre was 419 pounds. In 1925 the average daily gain for the lambs was 0.51 pound and the total gain was 480 pounds per acre, besides furnishing pasture for eight ewes until October 10. Similar alfalfa cut for hay yielded 5 tons per acre from the three cuttings. When pasturing sheep on alfalfa it must be borne in mind that certain losses from bloat may occur, although

there have been no losses during the 10 years of this experiment. Farmers on the project who pasture sheep in large numbers have sustained losses, but they have not been considered any heavier than those which occur on the range from other causes. To attain the best results the pasture should be divided into two equal parts and the sheep changed from one to the other about every two weeks. It is much safer to pasture lightly than too closely, and more satisfactory gains are obtained.

The corn plot in rotation 71 was pastured with lambs, and while on this corn the lambs also had access to the alfalfa plot that was pastured during the summer and the beet tops from the beet plot. In 1924 and 1925 good alfalfa hay in the rack was substituted for the alfalfa pasture. The lambs were turned in on the corn early in September, but while the alfalfa pasture was still good grazing they spent very little time in the corn. For this reason alfalfa hay was substituted for the pasture, and from the results obtained it seems to be a more desirable practice. During the first two weeks the lambs gradually cleaned up the leaves and husks of the corn and then got into the grain. In no year was there any bad effect from the overfeeding of corn. After the first week in October beet tops were supplied in addition to the pasture or hay. Table 20 shows the results of the experiment with lambs from 1916 to 1925, inclusive.

TABLE 20.—*Results of harvesting corn with lambs at the Belle Fourche Field Station, 1916–1925*

Year	Lambs			Corn		Average gain of lambs	
	Number per acre	Pasturing period	Average initial weight	Acre yield	Fed per pound of gain	Per acre	Daily per lamb
		Days	*Pounds*	*Bushels*	*Pounds*	*Pounds*	*Pounds*
1916	40	62	65	52.0	4.9	600	0.24
1917	48	42	72	57.0	4.4	724	.36
1918	32	60	72	55.0	5.1	600	.31
1919	32	42	71	30.0	3.4	496	.37
1920	28	43	65	42.0	5.3	440	.37
1921	24	63	91	53.0	5.6	528	.35
1922	40	73	47	60.0	6.3	536	.18
1923	40	56	64	59.0	6.5	504	.22
1924	32	49	64	38.0	4.4	488	.31
1925	52	33	81	45.1	2.9	876	.51
Maximum	52	73	91	60.0	6.5	876	.51
Minimum	24	33	47	30.0	2.9	440	.18
Average	37	52	69	49.1	4.9	579	.32

The average acre yield of corn for the 10-year period was 49.1 bushels. The corn was pastured at the average rate of 37 lambs per acre; the average length of pasturing period was 52 days; the average initial weight was 69 pounds; and an average of 4.9 pounds of corn was fed to make 1 pound of gain. The average total gains per acre were 579 pounds from 1 acre of corn supplemented with 1 acre of beet tops and alfalfa pasture or hay in the feed rack. In 1924 it required 1 acre of corn, yielding 38 bushels, 1 acre of beet tops, and 1,200 pounds of alfalfa hay to make a gain of 488 pounds. It thus required 4.4 pounds of corn to make 1 pound of gain. The average daily gain per lamb was 0.31 pound. The best results from harvest-

ing corn with lambs were obtained in 1925, when the lambs made a total gain of 876 pounds from 1 acre of corn, estimated at 45 bushels, 1 acre of beet tops, and 2,500 pounds of alfalfa hay. The average daily gain was 0.51 pounds per day for a period of 33 days. It required 2.9 pounds of corn and 2.8 pounds of hay to make 1 pound of gain. In addition to this the lambs had access to the beet tops from 1 acre in this same rotation.

PASTURING ALFALFA WITH HOGS

In two of the irrigated rotation experiments, rotations 65 and 69, the third year of alfalfa was pastured with hogs. The season was divided into two periods. Fall pigs were used during the spring period, which extended from about May 15 to July 15, and spring pigs were used during the summer period, lasting from the middle of July to the middle of September. The plots in these rotations were one-fourth acre in size, and each plot was divided into two equal areas, the hogs being alternated from one area to the other every 12 to 14 days. The pigs were fed a daily ration of corn equal to 2 per cent of their total weight and were weighed at the end of every 14-day period. The plots were pastured during the spring period at the approximate rate of 20 fall pigs with an average initial weight of 120 pounds, and during the summer period at the rate of about 30 spring pigs with an average initial weight of 50 pounds. The average live weight carried per acre in rotation 65 for the 13-year period was 2,123 pounds and in rotation 69 for the 11-year period 2,182 pounds. Table 21 shows the results of pasturing alfalfa with hogs from 1913 to 1925, inclusive.

TABLE 21.—*Results of pasturing alfalfa with hogs in rotations 65 and 69 at the Belle Fourche Field Station, 1913–1925*

Year	Rotation No.	Length of test (days)	Weight, acre basis (pounds)			Grain fed per pound of gain (pounds)
			Live weight	Grain fed	Gain	
1913	65	94	1,808	4,292	1,068	4.01
1914	65	121	1,815	5,104	1,830	2.79
1915	65	132	2,002	4,787	2,024	2.36
	69	132	2,060	4,976	2,108	2.36
1916	65	119	2,286	5,290	1,962	2.70
	69	119	2,238	5,128	2,006	2.56
1917	65	119	1,956	4,504	1,742	2.64
	69	119	1,956	4,464	1,740	2.56
1918	65	121	1,934	4,880	1,942	2.51
	69	121	1,979	4,880	2,138	2.28
1919	65	109	2,072	4,444	1,714	2.60
	69	109	2,062	4,444	1,688	2.63
1920	65	122	2,124	5,228	2,024	2.58
	69	122	2,124	5,228	2,032	2.57
1921	65	118	1,945	4,776	1,942	2.46
	69	118	1,964	4,776	2,004	2.38
1922	65	114	2,156	4,908	1,886	2.60
	69	114	2,168	4,908	1,932	2.54
1923	65	125	2,290	5,928	2,082	2.85
	69	125	2,344	5,928	2,260	2.62
1924	65	121	2,823	6,712	1,862	3.54
	69	121	2,816	6,712	1,866	3.53
1925	65	137	2,391	7,412	2,500	2.96
	69	137	2,295	7,636	2,100	3.65
Average:						
Rotation 65 (13 years)		119	2,123	5,251	1,890	2.81
Rotation 69 (11 years)		122	2,182	5,371	1,989	2.70

In 1924 and 1925 the weight of grain required per pound of gain was somewhat larger than in previous years. This may be partly explained. In 1924 the average live weight per acre was more than 2,800 pounds, and during this pasturing period the alfalfa was rather overpastured. In 1925 the feed requirement was also higher than in the period previous to 1924, and this may have been due to the rather poor quality of corn grown in 1924. During the 11-year and 13-year periods the grain requirement for a pound of gain was 2.7 and 2.81 pounds of corn, respectively, on good alfalfa pasture.

PASTURING CORN WITH HOGS

The spring pigs used in the pasturing experiment on alfalfa during the summer period were also used for harvesting the corn in the same rotations. The corn was pastured at the acre rate of about 16 pigs with an average initial weight of 85 pounds each. While pasturing the corn the pigs also had access to the alfalfa plot in each rotation that had been pastured during the summer. During the 11-year and 14-year periods that this experiment has been in progress the average estimated yield of corn was 50 bushels per acre. The average length of the test was about 26 days, the average live weight of the hogs when turned on the corn was about 1,350 pounds, and the total gains per acre approximately 686 pounds. The average daily gain per pig for the period was approximately 1.65 pounds, and 4.2 pounds of corn was required to make 1 pound of gain. Table 22 shows the results of harvesting corn with hogs from 1912 to 1925, inclusive.

TABLE 22.—*Results of harvesting corn with hogs in rotations 65 and 69 at the Belle Fourche Field Station, 1912–1925*

Year	Rotation No.	Length of test	Weight, acre basis		Corn		Average per pig	
			Total initial	Gain	Estimated acre yield	Fed per pound of gain	Initial weight	Daily gain
		Days	*Pounds*	*Pounds*	*Bushels*	*Pounds*	*Pounds*	*Pounds*
1912	65	26	680	340	28.7	4.7	85	1.63
1913	65	11	1,632	560	34.0	3.4	51	1.59
1914	65	20	1,708	582	34.8	3.3	106	1.81
1915	65	15	1,620	548	40.6	4.2	81	1.85
	69	10	1,780	451	34.0	4.2	89	1.87
1916	65	24	1,252	518	59.1	5.9	104	1.80
	69	26	1,268	456	47.7	5.8	105	1.53
1917	65	30	1,280	682	67.4	5.5	108	1.60
	69	37	1,206	537	55.4	5.7	109	1.38
1918	65	33	1,530	758	55.8	4.1	95	1.43
	69	35	1,190	667	56.7	4.7	99	1.58
1919	65	32	1,342	642	40.9	3.5	67	1.00
	69	32	998	554	40.0	4.0	62	1.08
1920	65	19	1,466	682	42.8	3.5	74	1.79
	69	28	1,025	703	43.6	3.5	73	1.89
1921	65	32	1,240	1,034	63.7	3.4	77	2.02
	69	26	1,087	866	52.7	3.5	77	2.38
1922	65	37	1,480	962	68.1	3.9	74	1.30
	69	37	1,323	1,035	68.9	3.7	74	1.50
1923	65	24	1,492	854	64.7	4.2	74	1.78
	69	24	1,423	728	53.2	4.2	79	1.69
1924	65	16	1,424	428	32.0	4.2	89	1.67
	69	16	1,750	512	37.0	4.0	87	1.60
1925	65	30	1,812	1,080	68.9	3.6	91	1.80
	69	30	1,814	978	68.2	3.9	101	1.81
Average:								
Rotation 65 (14 years)		25	1,426	691	50.1	4.1	84	1.65
Rotation 69 (11 years)		27	1,351	681	50.7	4.3	87	1.66

Harvesting certain crops with livestock seems to be a desirable practice. Some of the advantages are the saving of labor, which may include harvesting, feeding, and the hauling of manure. In the rotation experiments the most outstanding fact is the increase in yields of all the crops in the rotations where pasturing is practiced. A higher return per acre has also been obtained where the crop is harvested with livestock than when harvested in the ordinary manner.

PASTURING SHEEP

The farm flock of sheep was increased in the fall of 1923 to 32 range ewes and 20 purebred Hampshire ewes. These ewes were 5 or more years old. In the early fall the sheep had the run of the farm. The feeding of alfalfa hay was commenced on November 15 and continued until May 1, when the ewes were turned out on pasture. Part of this pasture was alfalfa and part brome grass. During the winter the total hay consumption for the 52 ewes was 23.5 tons of first-cutting alfalfa for a period of 166 days, which is about 5.5 pounds per head per day. Grain was fed from February 10 to May 1, consisting of equal parts of whole oats and shelled corn by weight. The lambs had access to grain in a creep. All the ewes were bred to a purebred Hampshire ram. The lambs were dropped from March 15, to April 1, 62 being raised from the 52 ewes. On May 1, when turned into the pasture, the lambs averaged 33 pounds in weight. On May 29, part of the lambs and range ewes were placed on alfalfa pasture and part on native pasture. The others of the flock were kept on the mixed pasture of alfalfa and brome grass. On August 7 the average weight of all the lambs was 92 pounds.

The lambs on native pasture made an average daily gain of 0.42 pound and those on alfalfa 0.5 pound. During June and early July the lambs on native pasture made gains as good as those on alfalfa, but in late July and early August the gains on the native grass were much less. The ewes lost in weight as the feed in the native pasture dried up. The lambs in the alfalfa pasture were sold at this time, but the ewes were continued on this pasture until October 1. The average clip for the purebred Hampshires was 6.8 pounds of wool per head, and the range ewes averaged 9.5 pounds.

During the winter of 1924–25 there were 42 breeding ewes, 12 being purebred Hampshire and 30 range ewes. In addition to these there were 25 yearling ewes, 9 of them being purebred Hampshire and 16 half-blood Hampshire. Two purebred Hampshire rams were carried through the winter. The total hay consumption from November 24, 1924, to April 30, 1925, for the entire flock of 69 head was 40,300 pounds of first-cutting alfalfa, which averages about 3.7 pounds per head per day. In addition to the hay they had the run of the farm. The winter was open and the hay consumption was light up to February 1. The total grain consumed by the breeding ewes was 2,500 pounds, equal parts by weight of whole oats and shelled corn.

Lambing commenced March 15 and was finished by April 1. From the 42 breeding ewes 58 lambs were raised. On May 1, when they were turned into pasture, the average weight of the lambs was 30.8 pounds. The flock was divided into three pasture lots—alfalfa, sweet clover, and native. On August 6 the average weight of all lambs was 82.4 pounds. The purebred lambs on sweet-clover pasture made

better gains than the grade lambs, averaging 91.5 pounds as compared with 80.5 pounds for the grades. Comparing the average daily gains of lambs from May 16 to August 6, the lambs on alfalfa gained 0.48 pound, those on sweet clover 0.56 pound, and those on native pasture 0.35 pound per head per day. The carrying capacity and gains on alfalfa pasture have been previously stated. The lambs on the sweet-clover pasture made the best average daily gain. No accurate figure can be given on the carrying capacity of sweet clover, as not all of this pasture could be irrigated.

The average weight of fleece from the old purebred Hampshire ewes in 1925 was 7.85 pounds; range ewes, 10.42 pounds; purebred Hampshire yearlings, born in 1924, 9.5 pounds; grade Hampshire yearlings, born in 1924, 10.64 pounds. The prices for lambs and wool have been very satisfactory to the grower during the last two years.

FEEDER-PIG PRODUCTION [6]

In 1923 an experiment was begun to determine the feed required to produce pigs weighing about 100 pounds. Purebred Duroc-Jersey sows were used during the three-year test. The 19 sows used in 1923 consisted of 5 three year-olds, 9 two-year-olds, and 5 one-year-olds. During the gestation period the sows were fed a grain ration of 3 pounds a day, consisting of 48 parts ground oats, 48 parts ground wheat, and 4 parts shelled corn; also 4 pounds of half-sugar beets with alfalfa hay in racks. During the suckling period, as soon as the sows were through farrowing, they were placed on self-feeders. The grain ration was 56 parts shorts, 17 parts ground barley, 27 parts shelled corn, and alfalfa hay self-fed in racks. The 19 sows farrowed 152 pigs, of which 76 were alive at weaning May 29. The grain consumption per sow and litter was at the rate of 10 pounds a day during the suckling period.

In 1924 the sows were fed during the gestation period 4 pounds of grain per day, consisting of 75 parts ground wheat and 25 parts shelled corn, and 4 pounds half-sugar beets with third-cutting alfalfa hay in racks. During the suckling period they were placed on self-feeders. The grain ration was 40 parts ground barley, 39 parts shelled corn, 18 parts shorts, and 3 parts wheat, with half-sugar beets, third-cutting alfalfa hay in racks, and 26 days on alfalfa pasture. From the 22 sows, 150 pigs were farrowed, of which 90 were alive at weaning June 13. The sows consisted of 4 gilts 1 year old and 18 sows that had previously raised one or more litters. The grain consumption per sow and litter was at the rate of 10.8 pounds per day during the suckling period.

In 1925 there were 21 breeding sows, 10 of which had raised one or more litters, and 11 gilts. During the gestation period the grain ration per day was 5.3 pounds for the old sows and 4 pounds for the gilts. This ration consisted of 28 parts corn, 48 parts barley, and 24 parts oats. The oats and barley were ground. In addition to this ration there were fed 6 pounds half-sugar beets with third-cutting alfalfa hay in racks. During the suckling period the 21 sows were fed ground feed in self-feeders, consisting of 66⅔ parts barley and

[6] An experiment conducted in cooperation with the Animal Husbandry Division of the Bureau of Animal Industry.

33⅓ parts oats, and in addition half-sugar beets, third-cutting alfalfa hay in racks, and 26 days on alfalfa pasture. The pigs had access to shelled corn in the creep. The old sows farrowed 61 pigs and raised 34, and the gilts farrowed 102 pigs and raised 79. The total weight of the old sows and boar at the beginning of the gestation period was 4,237 pounds and at the end of the suckling period 5,538 pounds, which was an average gain of 130.6 pounds for each of the sows, while the boar lost 5 pounds. The total weight of the gilts and young boar at the beginning of the gestation period was 2,119 pounds and at the end of the suckling period 3,307 pounds, which was an average gain of 89.3 pounds for each of the gilts and a gain of 206 pounds for the boar. In addition to these gains, a total of 113 pigs were raised, the total weight of which was 3,628 pounds at weaning. The grain consumption per sow and litter was 11.5 pounds per day during the suckling period. The average length of the suckling period for the three years was 75 days.

Table 23 shows the feed requirement during the gestation and suckling periods in 1923, 1924, and 1925.

The three-year average of feed required to produce 100 pounds of weight at weaning was 682 pounds of grain, 331 pounds of half-sugar beets, 265 pounds of third-cutting alfalfa hay. The average number of pigs raised per sow was 4.5, and the average weight per pig at weaning was 37 pounds. The average weight of grain required to produce a 37-pound pig was 247 pounds. The average grain requirement per weaned pig may seem somewhat high, but this is due in part to the fact that all grain consumed by the sows and boar during the gestation and suckling periods has been charged to the pigs without allowing for the gains made by the mature animals.

TABLE 23.—*Feed requirements of spring pigs during the gestation and suckling periods at the Belle Fourche Field Station in 1923, 1924, and 1925*

Year	Per pig			Per 100 pounds of gain			Average of weaned pigs	
	Grain	Half-sugar beets	Alfalfa	Grain	Half-sugar beets	Alfalfa	Number per sow	Weight
								Pounds
1923	215	106	71	632	312	209	4.0	34
1924	274	73	158	623	166	359	4.1	44
1925	253	165	73	791	516	228	5.4	32
Average	247	115	101	682	331	265	4.5	37

At the beginning of the pasture periods in 1923, 1924, and 1925 the pigs were divided into 2 lots. The average weight of each lot for the three-year period was 36 pounds. Lot 1 was fed at the rate of 1 pound of shelled corn per head per day and lot 2 at the rate of 1½ pounds of shelled corn per head per day. This ration was constant throughout the pasturing period. The 1½-pound ration is about the same as a 2 per cent ration, which has been used in previous tests, but there is the difference that the pigs receive relatively more grain during the early part of the pasturing period than when they are small. A 2 per cent ration means that a pig is fed grain equal to 2 per cent of its live weight, which is not sufficient to keep

a pig in good growing condition immediately after weaning. The 1½-pound ration at the beginning of the pasturing period is very nearly a full ration, and as the pig increases in size it is better able to utilize the alfalfa. The pasture period for 1923 was 113 days, for 1924 it was 112 days, and for 1925 it was 114 days. A constant ration is very much simpler to use, as the feed can be weighed or measured according to the number of pigs in the lots, but with a 2 per cent ration, based on live weight of the pigs, the ration is constantly changing and the pigs must be weighed frequently to determine the quantity of feed required. The data for the pasture period are given in Table 24.

In 1923 and 1924 there were 60 pigs in each lot. The pigs that were bought to make up this number were charged with the same feed requirement as those raised on the station. In 1925 there were 53 pigs in each lot, all raised on the station. During the pasture period for the three years lot 1 made the cheaper gain. The average for the 3 years is 248 pounds of corn per 100 pounds of gain with good alfalfa pasture. Lot 2, fed 1½ pounds of corn per day, has a 3-year average of 277 pounds of corn to make 100 pounds of gain. This is a difference of 29 pounds required for 100 pounds gain, however, figuring the total grain requirement for the whole period including gestation, suckling, and pasturing. Lot 2 required slightly less grain for 100 pounds gain.

The oats and barley used in this test were of very good quality, having a test weight of at least 37 and 48 pounds respectively. The corn used would grade No. 3 white.

TABLE 24.—*Feed requirements, in pounds, of spring pigs during the pasturing period at the Belle Fourche Field Station in 1923, 1924, and 1925*

Year	Average per pig								Grain requirements per 100 pounds of gain			
	Weight				Gain							
	Initial		Final		Total		Daily		Pasture period		Gestation, suckling, and pasture periods [1]	
	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2
1923	34	34	94	101	60	67	0.53	0.59	236	252	380	380
1924	42	42	94	102	52	60	.46	.54	215	280	397	420
1925	33	33	72	90	39	57	.34	.50	292	300	521	480
Average	36	36	87	98	50	61	.44	.54	248	277	433	427

[1] The figure for grain requirement per 100 pounds of gain for the gestation, suckling, and pasture periods combined is derived as follows:

Let a=the grain requirement per pig for the gestation and suckling period (Table 23).
Let b=the grain requirement per pound of gain during the pasture period (Table 24).
Let c=the total gain per pig during the pasture period (Table 24).
Let d=the final weight per pig at the end of the pasture period (Table 24).
Whence $\frac{a+(b\times c)}{d}$=grain requirement for the whole period.

The pasture requirement during the test was at the rate of about 30 pigs per acre in both lots. At the beginning of the test this was more alfalfa than the pigs would consume, and it was necessary to clip part of the pasture in order to have young growing alfalfa all

the time. It is well to have the pasture divided into two lots so that the pigs can be changed about every two weeks. This arrangement allows for a more uniform growth of alfalfa and for convenience in irrigating. Alfalfa handled in this manner will produce from 1,500 to 2,000 pounds of pork per acre with supplemental feed of 1 to 1½ pounds of corn per pig daily.

Whether to sell the pigs as feeders or to carry them through to finished weight will depend in part on market conditions at the close of the pasturing period and in part on whether there is sufficient grain feed on the farm that is to be marketed through livestock. The probable market price at the end of the fattening period as compared with the earlier market must also be considered. Where the feed is available on the farm, it seems advantageous to carry the hogs through to a finish, particularly when they are used to harvest corn in the field. Hogs handled in this manner with access to alfalfa pasture or good third-cutting alfalfa hay in racks make economical gains, as has been shown in previous pages of this publication. The grain requirement for the second 100 pounds for a finished hog is no larger than for the first 100 pounds and the labor requirement is much less. The saving of labor and the increased yields on crops that follow, resulting from this practice, are items well worth considering.

DRAINAGE

Irrigation water was first brought to the Belle Fourche Field Station in 1912, through the town-site lateral. This lateral is about 15 feet wide at the bottom and from 3 to 4 feet deep. There are places where this canal cuts into the porous shale, and at these points evidences of seepage have appeared in the fields below the canal. The first evidence of seepage appeared in field A in 1915 (fig. 4.) A 4-inch tile drain was placed in this area at a depth of 4 to 5 feet, but in spite of this tiling the seepage continued to spread, as is shown by areas 1 and 2 in the figure. In 1920 new seeped areas appeared, numbered 3 and 4 in the figure, and in 1924 seepage began to show in areas 5 and 6. As these seeped areas have developed, tile has been placed to drain them. In the fall of 1916 two 6-inch tile drains were laid, one at the upper edge of the seeped areas 1 and 2 and the other at the lower end of these areas. The distance between the drains was about 145 feet. Before locating these drains, borings were made with a 4-inch auger to determine the character of the soil and the depth to underground water. It was found that the underlying shale was stratified and filled with water. Down the slope, from 300 to 500 feet from the canal, the water pressure in this stratified shale was great enough to force the water to the surface of the ground.

The soil of this field is a heavy gumbo, technically known as Pierre clay. This soil has resulted from the weathering of the original shale, which is now covered by a soil blanket in some places as much as 5 feet in thickness. In many places the soil cover is much thinner, particularly on hillsides. The layers of shale are not level, but are sloping or folded. The upper layers are not only stratified, so that water may move laterally between the layers, but they are also cracked and fissured in the exposed places, so that water readily soaks through them. The

soil blanket above the shale is fine grained and swells so much when it is wet that water moves through it very slowly. The deeper layers of shale are very compact, and while clearly stratified they are not much fissured and do not absorb much water or permit water to soak

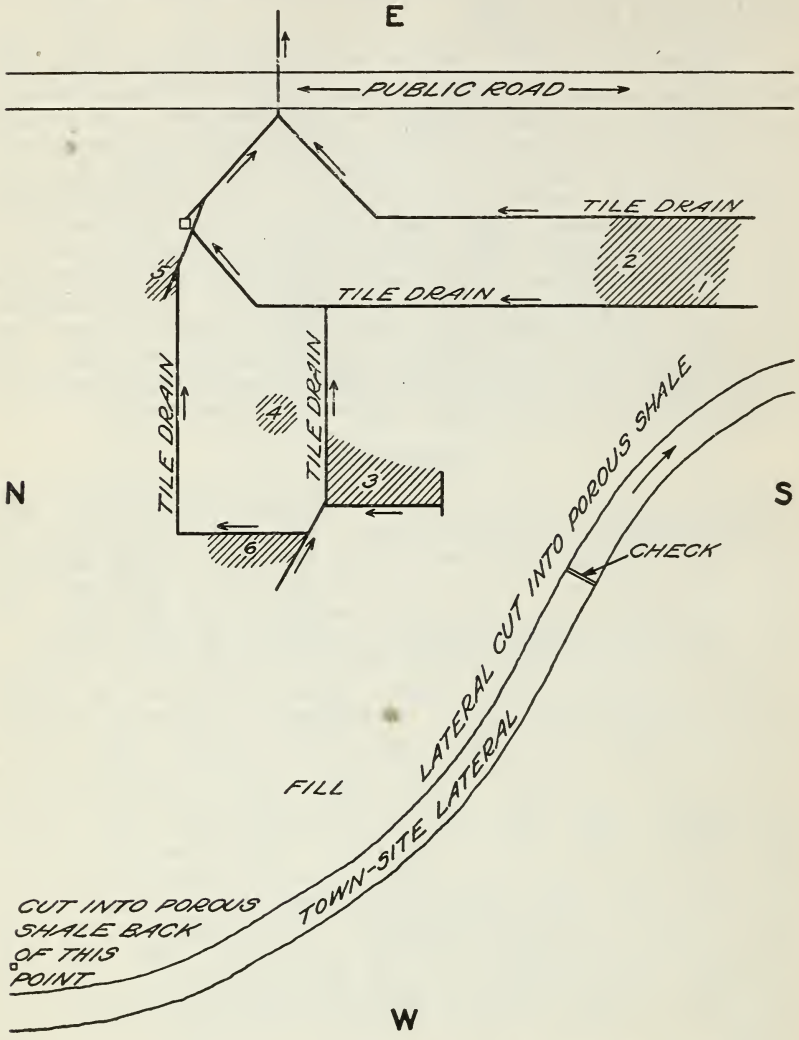

FIG. 4.—Diagram showing the location of seepage areas near the south end of field A of the Belle Fourche Field Station. The numbers in the shaded areas indicate the sequence in which the seepage developed

downward. The result is that there is a well-defined bed of cracked and fissured shale lying between the soil blanket above and the compact shale below. Through this zone of fissured shale, water moves almost as readily as it would move through a zone of coarse sand or gravel.

When this zone of fissured shale is cut into by an irrigation canal, the water from the canal percolates along this porous bed if the slope is downward. If this bed is again cut below by a ravine or ditch, the seepage water escapes; but if there is no outlet and it dips and rises again the water accumulates at the low point under pressure and gradually soaks upward through the soil blanket to form a seepage spot. The salts absorbed by the water from the shale and soil through which it passes are deposited on the surface of the soil at the place of evaporation, so that seepage spots are often salty. These areas, which eventually become barren land, can be located a year or two earlier by the reduced crop growth on them; and if tests are made with an auger it generally will be found that the subsoil is saturated with water. If an outlet for this excess ground water can be provided at this stage, much time and expense can be saved in reclaiming the land.

Tile drainage is the only system which has been used at the Belle Fourche Field Station in reclaiming seeped land. The tile is laid underground at a depth of about 7 feet or at the bottom of the porous shale, so as to intercept the water as it passes down the slope over the rather impervious hard blue shale. This method has resulted in lowering the water level to such a depth that it ceases to have any injurious effect on plant growth, and the land reverts to a normal production basis within five or six years. After drainage has been provided, frequent irrigations should be applied so as to wash out the excess salts that have been deposited on the surface of the soil at the place of evaporation. Much of the seepage injury on the Belle Fourche project appears to be due to canal leakage at points where the canal has cut down into the porous shale and where natural drainage has not been sufficient to carry off this excess ground water, which as a result tends to seek its own level by rising to the surface of the soil.

The drainage situation is no more serious on the Belle Fourche project than elsewhere, and in many respects it is less so, as many natural drainage ways exist. However, to reclaim areas already injured by seepage and to prevent the development of others, some method should be devised to cut down canal losses. Some supplementary drainage may be necessary in certain places, and for this purpose either open drains or tile may be used.

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June, 1927

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